Soil Bin for Studying Planting Equipment and Systems

U.S. Department of Agriculture
Science and Education Adminstration
Advances in Agricultural Technology • AAT-W-4/February 1979

ABSTRACT

This paper discusses the design and construction of laboratory soil preparation equipment to provide controlled soil conditions for testing planting equipment and the evaluation of factors affecting seedling emergence. Detailed engineering drawings of the system and equipment are presented.

KEYWORDS: Soil bin, soil preparation equipment, seedling emergence, planter testing equipment.

A free copy of this publication is available from the Science and Education Administration, U.S. Agricultural Research Station, P.O. Box 5098, Salinas, Calif. 93915.

Science and Education Administration, Advances in Agricultural Technology, Western Series, No. 4, February 1979

Published by Agricultural Research (Western Region), Science and Education Administration, U.S. Department of Agriculture, Berkeley, Calif. 94705.

CONTENTS

	Page
Introduction	1
Objectives	2
Design requirements	2
Machine and system design	2
Soil bin	2
Soil preparation equipment	2
Planter tool bar	3
Power	3
Controls	3
Literature cited	4

SOIL BIN FOR STUDYING PLANTING EQUIPMENT AND SYSTEMS

By D. E. Wilkins, W. J. Conley, and P. A. Adrian[1]

INTRODUCTION

Precise preparation of soil and planting of seeds is important to research concerned with studying seedling emergence. Control of soil conditions is especially important in the development of systems and equipment for vegetable crop stand establishment because vegetable seedlings are extremely sensitive to harsh environments produced by moisture tension, soil compaction, soil impedance to mechanical penetration, and seed depth.

Fields tests and experiments are important and valuable, but weather constraints limit their usefulness; therefore, controlled laboratory studies should be an integral part of stand establishment research.

Soil bins are of two types: The tillage tools remain stationary and the soil bin moves or the soil bin remains stationary and the tools move. Several researchers have studied scale model and prototype tillage tools and tractive devices with stationary soil bins (*4*, *5*, *6*, *8*, *14*, *15*)[2] used for large volumes of soil. The concept of moving the soil and keeping the tools stationary has been widely used in model studies and soil dynamic research (*1*, *2*, *3*, *7*, *9*, *11*, *12*, *13*). None of these soil bins were designed to provide a controlled soil environment for an extended time subsequent to testing of tillage or planting equipment. Keating and Clark (*10*) designed a system for preparing soil samples that accommodated field size planting equipment. Their soil samples were 44 cm long, 37 cm wide, and 30 cm deep. This system provided a means of testing planter units and making evaluations based on seedling response but soil preparation was time consuming. There is a need to develop a system to test planter units, provide controlled soil temperature and light for seedling emergence subsequent to planting, and prepare soil for quick testing.

---

[1]Wilkins and Adrian are agricultural engineers and Conley is a mechanical engineering technician. All are located at the Agricultural Research Station, Science and Education Administration, 1636 East Alisal Street, Salinas, Calif. 93915.

[2]Italic numbers in parentheses refer to Literature Cited, p. 4.

OBJECTIVES

The objectives of this research were to design and construct laboratory soil preparation equipment to provide controlled soil conditions for testing planting equipment and evaluation of factors affecting seedling emergence.

DESIGN REQUIREMENTS

The design of the soil bin integrated requirements for operating speeds, soil preparations, portability of soil bin, and safety. The principle of having the tillage and planting equipment stationary and moving the soil relative to the equipment was adopted to meet the requirement for portability. This was accomplished by propelling a soil bin, containing the volume of soil being tested, along a track and past the tillage and planting equipment. Figure 1[3] shows the soil bin and track layout.

The design speed range for testing and/or preparing soil was 0 to 6.4 km/h (0 to 4 mi/h). If higher operating speeds are desired, a longer track or a more powerful drive is necessary to accommodate the acceleration and deceleration of the soil bin.

The soil preparation equipment required capability for compacting the soil, reducing soil aggregate size, loosening compacted soil, leveling the soil, and increasing the soil moisture content. Safety devices were included in the design to minimize the number of human decisions and control functions necessary to operate the system so that a maximum effort could be directed towards observation of the processes being conducted.

MACHINE AND SYSTEM DESIGN

Soil Bin

Figure 2 shows the soil bin configuration and dimensions. The soil bin can be lifted off the carriage with a forklift and moved to a greenhouse or growth chamber to observe emergence or to exchange for another soil bin (see figs. 2 and 3). Because growth chamber and greenhouse space are often limited, a means was provided to remove the end sections of the bin and then use the center section for emergence observations.

Soil Preparation Equipment

Figures 4 and 5 are engineering drawings of the scraper, roller, and tillage tool bar. A powered rotary tiller mounted on the tillage tool bar mixes soil, decreases soil bulk density, and reduces soil aggregate size (fig. 6). The tiller has 12 L-shaped blades mounted so that the knife edges rotate in a 23-cm (9 inches) diameter circle. The overall width of tillage is 66 cm (26 inches). A 0.75 kW (1 hp) motor powers the tiller at 175 r/min through a gear reducer. The vertical position of the tiller is controlled by a hydraulic ram.

---

[3]All figures follow the Literature Cited section.

Three flat spray nozzles, mounted directly in front of the tiller, apply water to the soil surface. The water is then thoroughly mixed into the soil by the tiller. Behind the tiller is a leveling scraper.

After the soil is wetted, tilled, and leveled, it then is consolidated with a powered roller. The 91.44-cm (36 inches) diameter roller is driven at groundspeed by a Char Lynn Orbitrol flow control and hydraulic motor. A solenoid activated clutch couples the Orbitrol to the carriage drive. The degree of soil compaction is determined by the position of the roller, which can be adjusted with a hydraulic ram.

Planter Tool Bar

Figure 7 shows a planter mounted on the tool bar and a power unit to drive the planter. A parallel linkage between the tool bar and the mounting frame keeps the test equipment parallel to the soil surface but allows vertical and side-to-side positioning of the test equipment. The vertical and side-to-side positioning are accomplished by using two hydraulic rams. Figure 8 is an engineering drawing of the planter tool bar frame.

Power

The soil bin is powered by a 1.5-kW (2 hp) d.c. motor with a silicon controlled rectifier (SCR) control and a 10-to-1 gear reducer. This provides speeds from 0 to 6.4 km/h (0 to 4 mi/h) in forward and reverse. Hydraulic power for the roller and hydraulic cylinders is provided by either a portable hydraulic power unit or a tractor with a remote hydraulic circuit. The hydraulic power requirements are 30 L/min (8 g/m) at 8,300 kPa (1,200 psi).

The planter power drive unit is a 0.37 kW (1/2 hp) motor with an SCR and a 10-to-1 speed reducer. This provides a range of speeds from 0 to 175 r/min.

Controls

The controls provide means for regulating speed, changing position of components, and nulling attempted incompatible operations. The hydraulic positioning controls for the roller, planter tool bar, power tiller, and leveling blade are manually operated valves located on the control panel. A diagram of the hydraulic circuit is shown in figure 9. The electrical schematic diagram is shown in figure 10.

The control unit for the cart and tillage operations consists of the following switches and associated indicator lights: (1) Run, (2) set, (3) return, (4) water, (5), tiller, and (6) stop. The run switch starts the carriage moving from right to left at the rate of speed set on the SCR control. The return switch starts the carriage moving from left to right at the rate of speed set on the SCR. The set switch starts the carriage moving from left to right at a fixed rate of speed, which is approximately 0.4 km/h (1/4 mi/h). The set switch also slowly returns the carriage to its start position. The water switch activates the water circuit and, if the tillage tool bar is lowered into position, the spray nozzles will automatically turn on and apply water to the soil as it passes and then automatically turn off. The tiller switch activates the power circuit to the tiller, which automatically starts the tiller as the soil bin

approaches and then automatically turns off after the bin passes. The stop switch stops all operations immediately. The planter drive control switch activates the planter power unit, and the motor automatically turns on and off as the soil bin passes.

LITERATURE CITED

(1) Barnes, K. K., Bockhop, C. W., and McLeod, H. E.
1960. Similitude in studies of tillage implement forces. Agric. Engr. 41(1): 32-37, 42.

(2) Batchelder, D. G., Porterfield, J. G., Chisholm, T. S., and McLaughlin, G. L.
1971. A continuous linear soil bin. Amer. Soc. Agric. Engr. Trans. 14(6): 1009, 1010, 1014.

(3) Chisholm, T. S., Porterfield, J. G., and Batchelder, D. G.
1972. A soil bin study of three-dimensional interference between flat plate tillage tools operating in an artificial soil. Amer. Soc. Agric. Engr. Trans. 15(1): 43-48.

(4) Clark, S. J., and Lilijedahl, J. B.
1968. Soil bins, artificial soils and scale-model testing. Amer. Soc. Agric. Engr. Trans. 11(2): 198-202.

(5) Cohron, G. T.
1966. Model testing of earthmoving equipment. Amer. Soc. Agric. Engr. Trans. 9(2): 201-202, 205, 212.

(6) Collins, E. R., and Lalor, W. F.
1973. Soil bin investigations of a deep working tillage tool. Amer. Soc. Agric. Engr. Trans. 16(1): 29-33.

(7) Fornstrom, K. J., Brazee, R. D., and Johnson, W. A.
1970. Tillage-tool interaction with a bounded artificial soil. Amer. Soc. Agric. Engr. Trans. 13(4): 409-416, 418.

(8) Freitag, D. R.
1968. Dimensional analysis of performance of pneumatic tires on sand. Amer. Soc. Agric. Engr. Trans. 11(5): 669-672.

(9) Johnson, C. E., Buchele, W. F.
1969. Energy in clod-size reduction of vibratory tillage. Amer. Soc. Agric. Engr. Trans. 12(3): 371-374.

(10) Keating, D. J., and Clark, S. J.
1973. Soil-media design for laboratory planter testing in natural soils using vibratory compaction. Amer. Soc. Agric. Engr. Trans. 16(1): 1-4.

(11) Larson, L. W., Lovely, W. G., and Bockhop, C. W.
1968. Predicting draft forces using model moldboard plows in agricultural soils. Amer. Soc. Agric. Engr. Trans. 11(5): 665-668.

(12) Reaves, C. A.
1966. Similitude of plane chisels in artificial soil. Amer. Soc. Agric. Engr. Trans. 9(2): 147-150.

(13) Schafer, R. L., Bockhop, C. W., and Lovely, W. G.
1968. Prototype studies of tillage implements. Amer. Soc. Agric. Engr. Trans. 11(5): 661-664.

(14) Siemens, J. C.
1964. A soil bin for model studies on tillage tools and traction devices. J. of Terramechanics 1(2): 56-67.

(15) Siemens, J. C., Weber, J. A., and Thornburn, T. H.
1965. Mechanics of soil as influenced by model tillage tools. Amer. Soc. Agric. Engr. Trans. 8(1): 1-7.

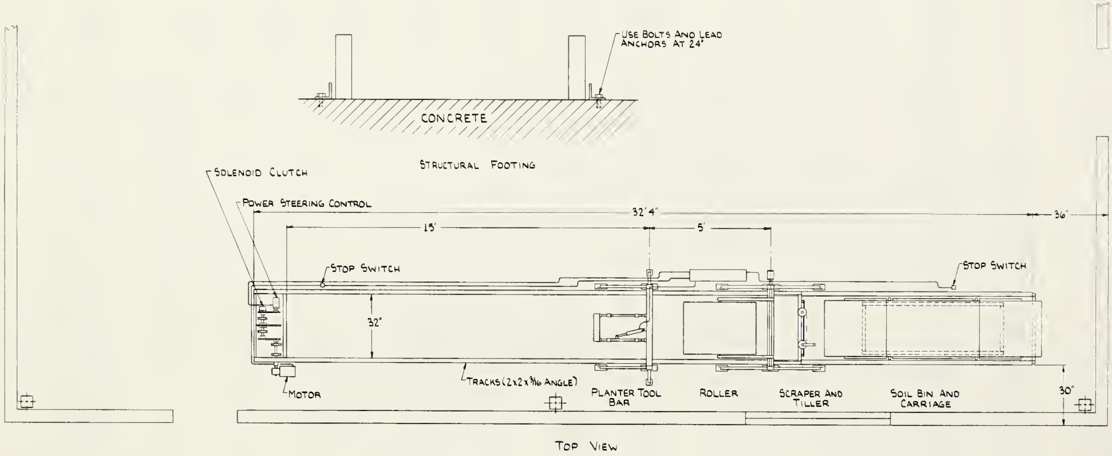


Figure 1.--Soil bin track layout.

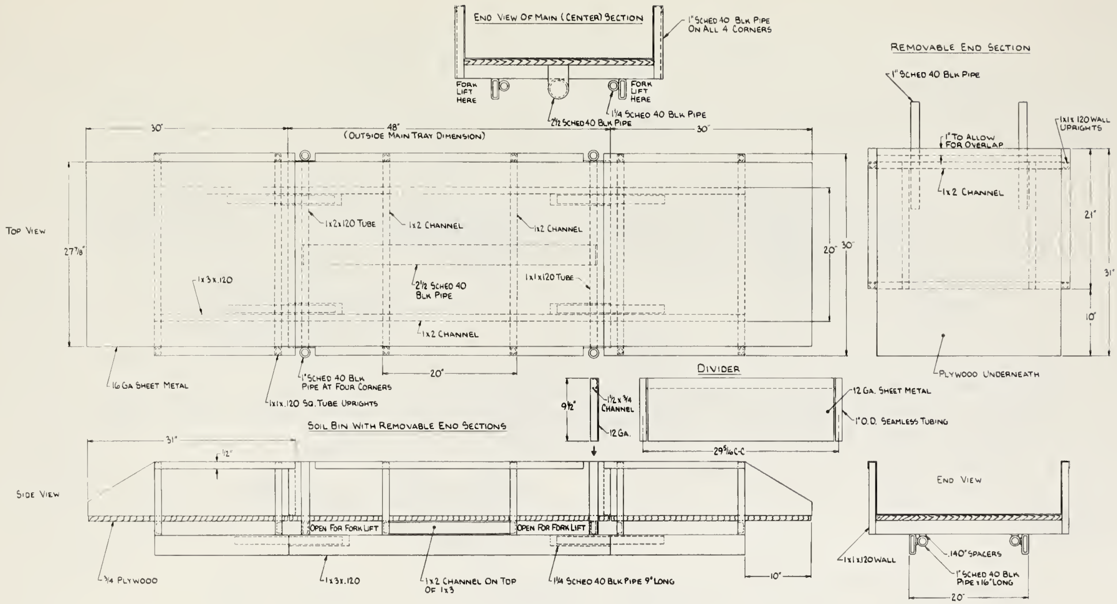


Figure 2.--Soil bin.

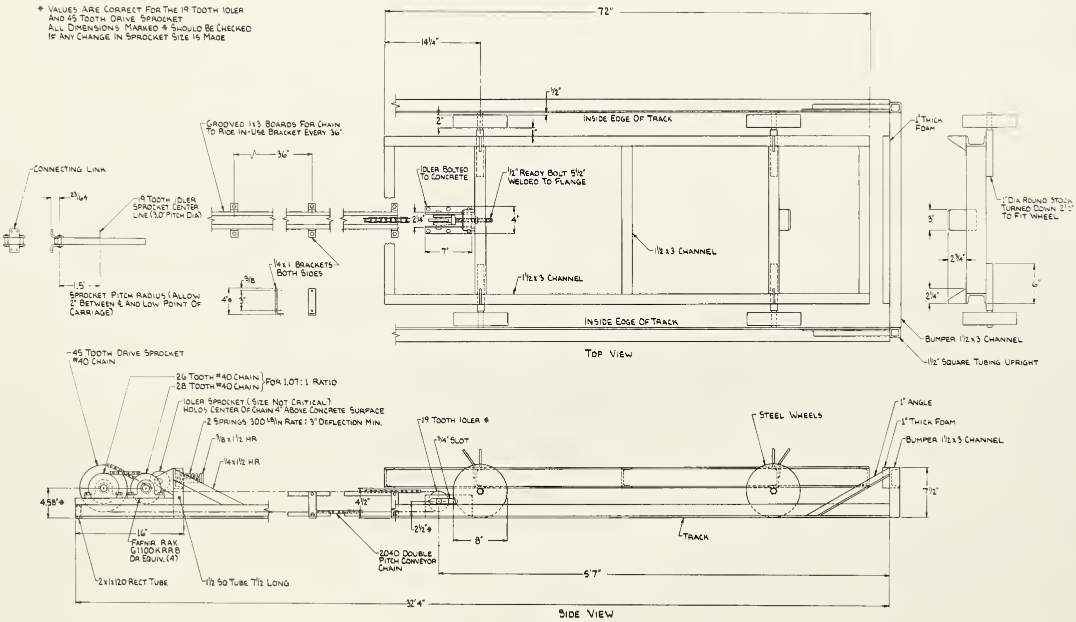


Figure 3.--Soil bin carriage and drive.

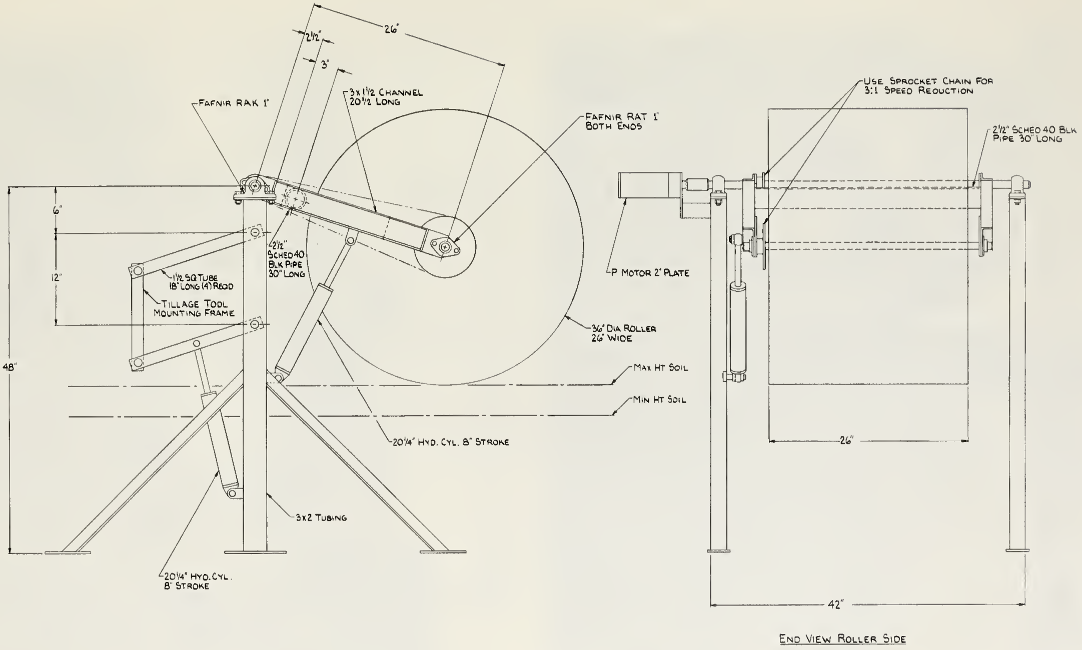


Figure 4.--Tillage and rolling frame.

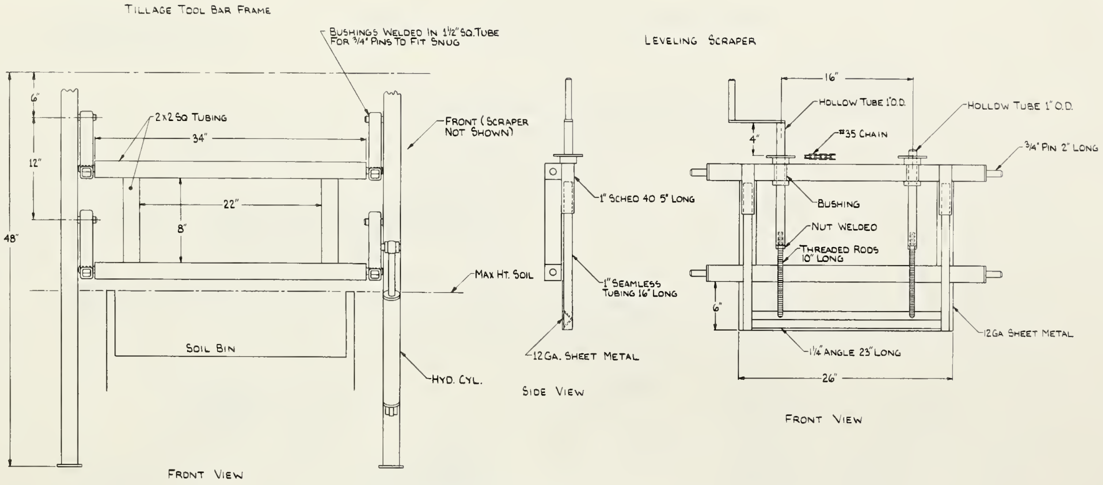


Figure 5.--Tillage tool bar and leveling scraper.

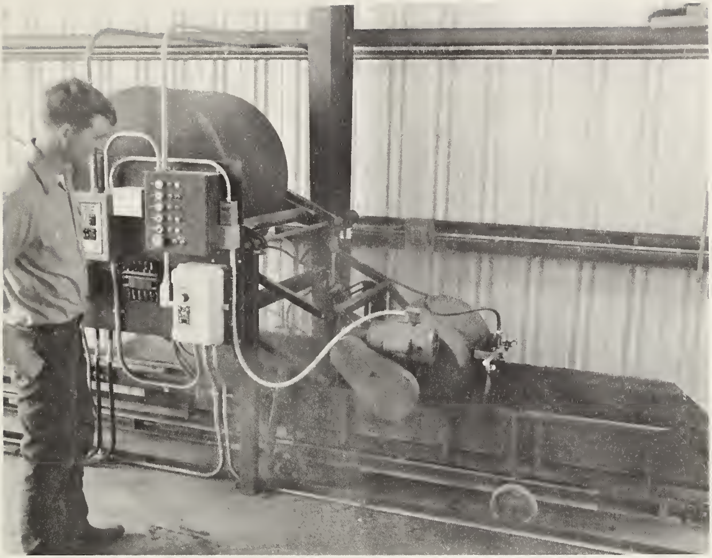


Figure 6.--Power rotary tiller in operation.
The soil bin control panel is on the left.

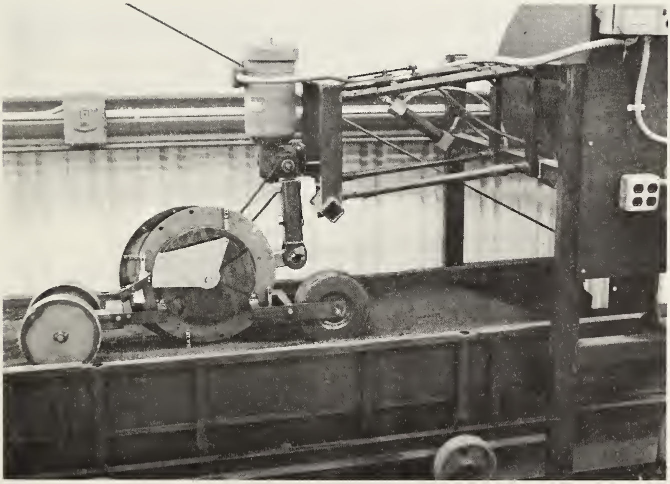


Figure 7.--Planter tool bar.

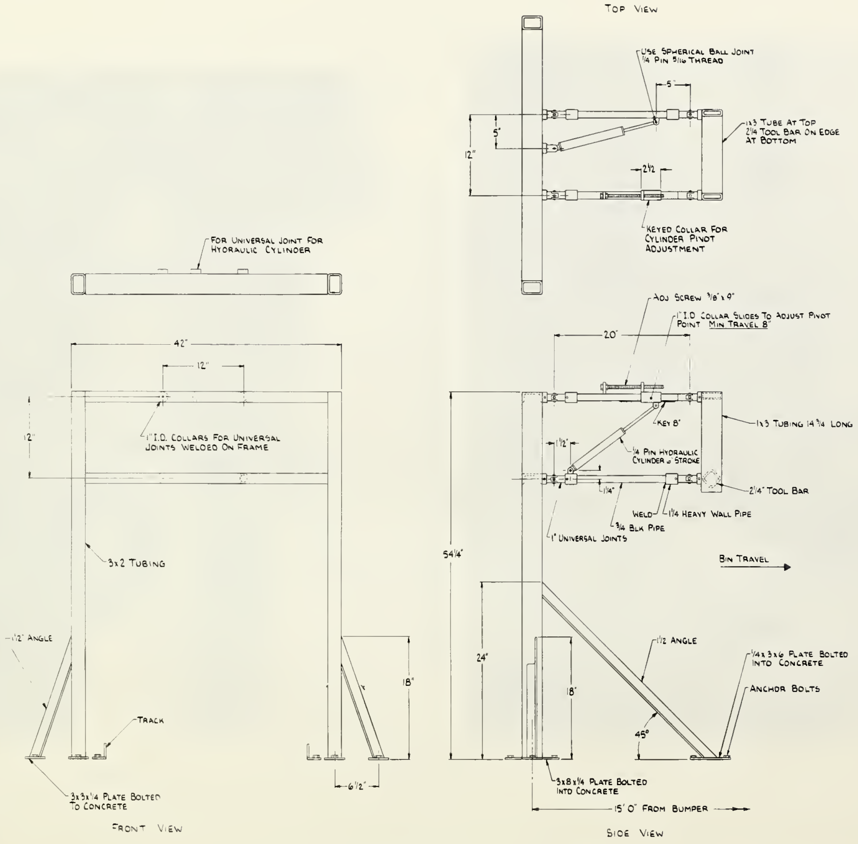


Figure 8.--Planter tool bar frame.

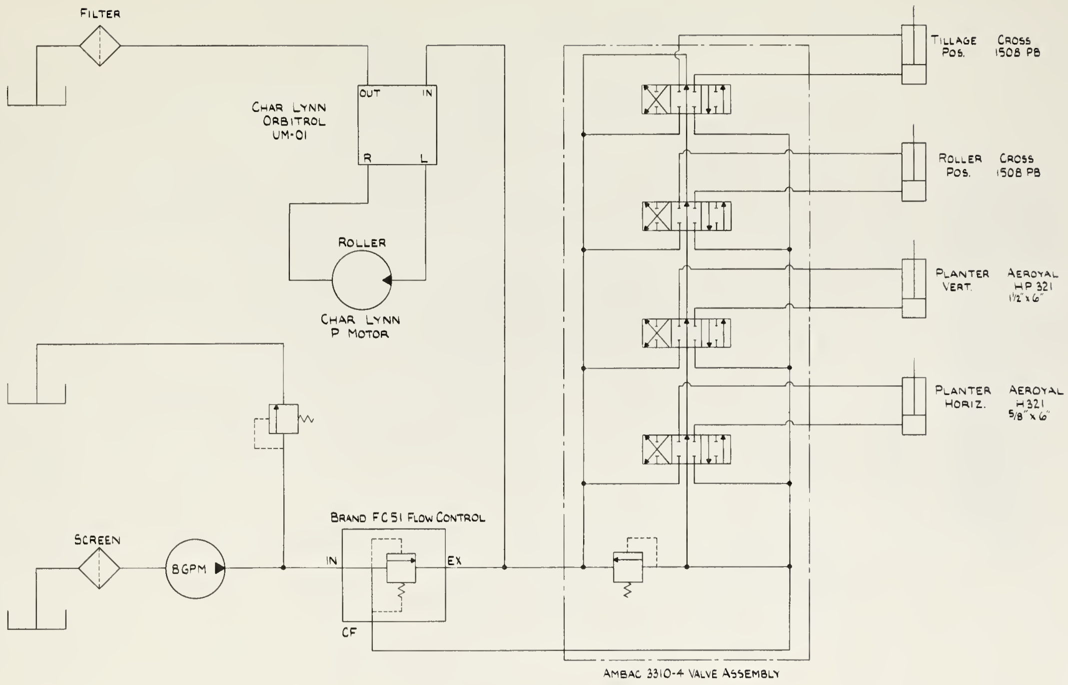
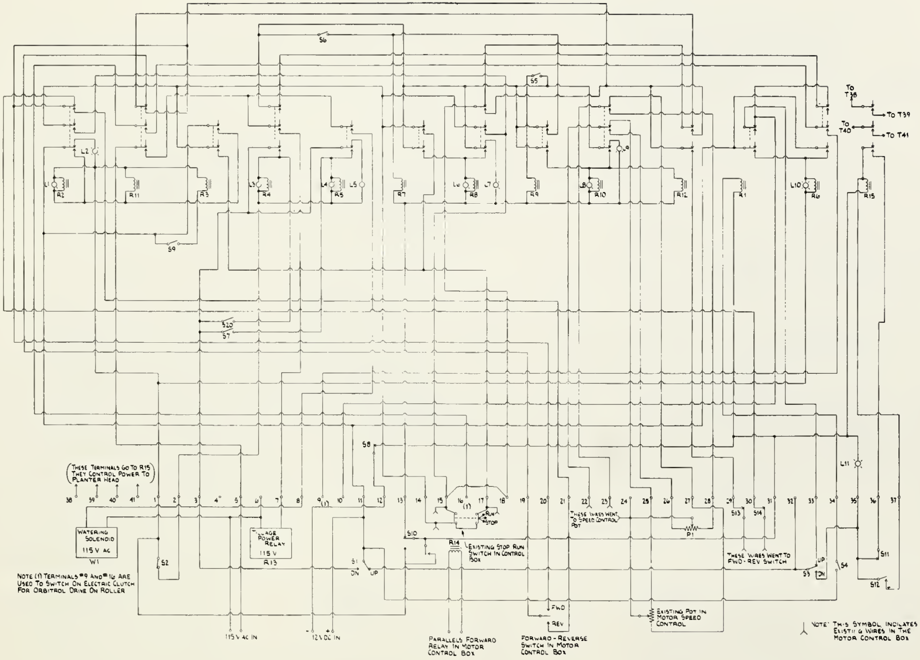


Figure 9.--Soil bin hydraulic circuit.



Symbol	Name
R1	Roller Relay #1
R2	Run Relay
R3	Start Relay
R4	Tiller Relay
R5	Water Relay
R6	Roller Relay #2
R7	Return - Start Relay
R8	Return Run Relay
R9	Set Relay
R10	Slow Speed Relay
R11	Run Relay #2
R12	Slow Speed Relay #2
R13	Tillage Power Relay
R14	Forward Relay
R15	Planter Relay
S1	Tillage Position Switch
S2	Tillage & Sprayer Stop Switch
S3	Planter Position Switch
S4	Roller Position Switch
S5	Set Switch
S6	Return Switch
S7	Water Switch
S8	Emergency Stop Switch
S9	Forward Start Switch
S10	Set Position Switch
S11	Planter Stop Switch
S12	Planter Start Switch
S13	Forward Stop Switch
S14	Reverse Stop Switch
S20	Tillage Switch
P1	Potentiometer
W1	Water Solenoid Valve
L1→ L11	Indicator Lampa

Figure 10 —Electrical schematic.

GPO 690-415

U. S. DEPARTMENT OF AGRICULTURE
SCIENCE and EDUCATION ADMINISTRATION
WESTERN REGION
1333 BROADWAY, SUITE 400
OAKLAND, CALIFORNIA 94612

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
U. S. DEPARTMENT OF
AGRICULTURE
AGR 101

U.S.MAIL

FIRST CLASS

Return the mailing label(s) to above address if:

- ☐ Your name or address is wrong (indicate corrections, including ZIP).
- ☐ You receive duplicate copies (include labels from all copies received).
- ☐ You do NOT wish to continue receiving this technical series.